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Environmental Ecology Learning Based on Geographic Information Systems in Wonogiri Regency

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Abstract

Land ecosystem degradation in Wonogiri Regency, characterized by seasonal drought, land degradation, and land use change, requires management approaches based on ecological principles and geospatial technologies. However, the utilization of Geographic Information Systems (GIS) in geography education remains suboptimal, particularly at the teacher level. Therefore, this community service activity aimed to enhance the capacity of geography teachers in the MGMP (Subject Teacher Forum) of Wonogiri Regency in understanding regional ecology and integrating GIS into geography learning. The method employed was participatory training based on a *service learning* approach through workshops, with evaluation conducted using pre-test, post-test, and questionnaires. The activity involved 21 geography teachers. The results showed that the average pre-test score of 9.81 increased to 10.00 in the post-test, representing a 1.94% improvement with an N-gain value of 0.037 (low category). The paired sample t-test indicated that the improvement was not statistically significant ($p > 0.05$). Nevertheless, questionnaire results revealed positive responses from participants, with the majority reporting increased understanding, ease of material comprehension, and readiness to implement GIS in teaching. This indicates that the workshop was more effective in enhancing affective aspects and implementation readiness rather than short-term cognitive improvement. In conclusion, this activity serves as an initial stage in developing geospatial-based teacher capacity. Further intensive and sustainable programs are required to achieve more significant improvements in learning effectiveness.

1. Introduction

Every interaction between biotic and abiotic components in nature forms a dynamic ecosystem (Odum & Barrett, 2005). Ecosystems exhibit different characteristics in each region, depending on physical conditions, climate, and human activities that influence them. In understanding these dynamics, ecology plays an essential role in examining the

relationships among ecosystem components and the processes occurring within them (Begon et al., 2006). Wonogiri Regency, Central Java, is characterized by hilly landscapes, karst areas, and dry agricultural land. In addition, the presence of the Gajah Mungkur Reservoir serves as a key element in the regional hydrological system and supports local livelihoods. These geographical characteristics provide Wonogiri with high ecological potential, but also expose it to complex environmental problems, such as seasonal drought, limited water resources, land degradation due to erosion, and uncontrolled land use changes (Badan Pusat Statistik Kabupaten Wonogiri, 2023).

These environmental challenges highlight the importance of ecosystem management based on ecological knowledge supported by geospatial technologies. Geographic Information Systems (GIS) and remote sensing play a strategic role in monitoring environmental conditions, analyzing land use changes, and supporting decision-making in natural resource management (Nizamani et al., 2024; Eastman, 2012). Through spatial visualization and analytical capabilities, these technologies enable more comprehensive and data-driven ecological assessments. GIS can be utilized to analyze ecosystem conditions using remotely sensed imagery (Sari et al., 2025). In addition, remote sensing facilitates environmental monitoring both before and after conservation efforts (Nyompa et al., 2023). The results of GIS-based analyses can also be used as a basis for evaluating ecosystem management policies (Mukasyaf et al., 2024).

In the context of education, the environmental conditions of Wonogiri Regency provide strong potential as contextual learning resources in geography education, particularly in environmental ecology topics. Context-based learning not only enhances students' understanding but also fosters ecological awareness and environmental responsibility from an early age (UNESCO, 2017). However, the use of spatial data and geospatial technologies in learning remains suboptimal, particularly in integrating GIS into classroom teaching (Kerski, 2008).

The Geography Teachers' Association (MGMP) of Wonogiri Regency plays a strategic role as a professional development platform for improving the quality of geography education. MGMP serves not only as a forum for discussion but also as a medium for enhancing teachers' pedagogical and professional competencies, including the use of geospatial technology in

learning. Therefore, a community service program is needed to strengthen teachers' capacity in understanding regional ecology and integrating Geographic Information Systems into geography learning in a contextual, analytical, and technology-based manner.

2. Methods of Implementation

This community service activity employed a participatory training approach based on *service learning*, combined with educational outreach methods and quantitative evaluation. This approach was selected as it integrates knowledge transfer with direct learning experiences, thereby enhancing both conceptual understanding and participants' readiness for implementation (Mukasyaf, 2024).

The educational outreach method was used to deliver fundamental concepts of environmental ecology and Geographic Information Systems (GIS), while the *service learning* approach was applied to evaluate learning effectiveness through active participant engagement in reflection and learning outcome assessment. The participants were teachers from the Geography Teachers' Association (MGMP) of Wonogiri Regency. They had a background in geography education and experience teaching environmental topics, although their use of GIS in teaching remained limited. The participants were selected purposively based on their relevance to the need for developing geospatial-based teaching competencies.

2.1 Implementation Stages

2.2.1.1 Preparation Stage

This stage aimed to ensure that the training materials were aligned with participants' needs, including:

- Coordination with the MGMP Geography of Wonogiri Regency
- Identification of training needs (*needs assessment*)
- Development of workshop materials based on the local context of Wonogiri Regency
- Preparation of evaluation instruments (pre-test, post-test, and questionnaires)

2.2.1.2 Workshop Implementation Stage

The activity was conducted as a one-day interactive workshop using an active learning approach.

a. Pre-test

Conducted before the workshop to assess participants' initial knowledge regarding:

- Environmental ecology concepts
- Basic GIS knowledge
- Experience in using technology in teaching

b. Material Delivery

The materials were delivered interactively by the service team, covering:

- Regional-based environmental ecology concepts
- Introduction to Geographic Information Systems (GIS)
- Integration of GIS in geography learning

c. Discussion and Reflection

Participants were actively involved in discussions to:

- Identify opportunities for classroom implementation
- Share teaching experiences
- Develop ideas for contextual learning

2.2.1.3 Evaluation Stage

Evaluation was conducted using a *service learning* approach with quantitative measurement, including:

a. Post-test

Conducted after the workshop to measure participants' improvement. The instrument covered:

- Ecology concepts
- GIS understanding
- Application in learning

b. Pre-test and Post-test Analysis

Data were analyzed descriptively by comparing:

- Scores before and after training
- Percentage of improvement

c. Questionnaire Evaluation

The questionnaire was used to assess:

- Perceptions of the material
- Participant satisfaction
- Readiness for classroom implementation

2.2 Data Analysis

Data analysis was conducted using descriptive quantitative methods, including:

2.2.1 Mean Analysis

Calculating the average scores of pre-test and post-test to identify trends in participants' learning improvement.

2.2.2 Percentage Increase Analysis

Using the formula:

$$Increase\ Analysis\ = \frac{Post\ Test - Pres\ Test}{Pre\ Test}\ x\ 100\ \%.....(1)$$

2.2.3 Normalized Gain (N-Gain) Analysis

Used to measure learning effectiveness with categories: low (<0.3), moderate (0.3–0.7), and high (>0.7) (Hake, 1999).

2.2.4 Statistical Test (Paired Sample t-test)

Used to determine the significance of differences between pre-test and post-test scores. The criteria are:

$p < 0.05 \rightarrow$ significant

$p > 0.05 \rightarrow$ not significant

This test is commonly used in educational research to evaluate learning outcomes before and after an intervention (Creswell, 2014).

2.2.5 Descriptive Analysis of Questionnaires

Questionnaire data were analyzed in percentages to describe participants' perceptions of the workshop comprehensively.

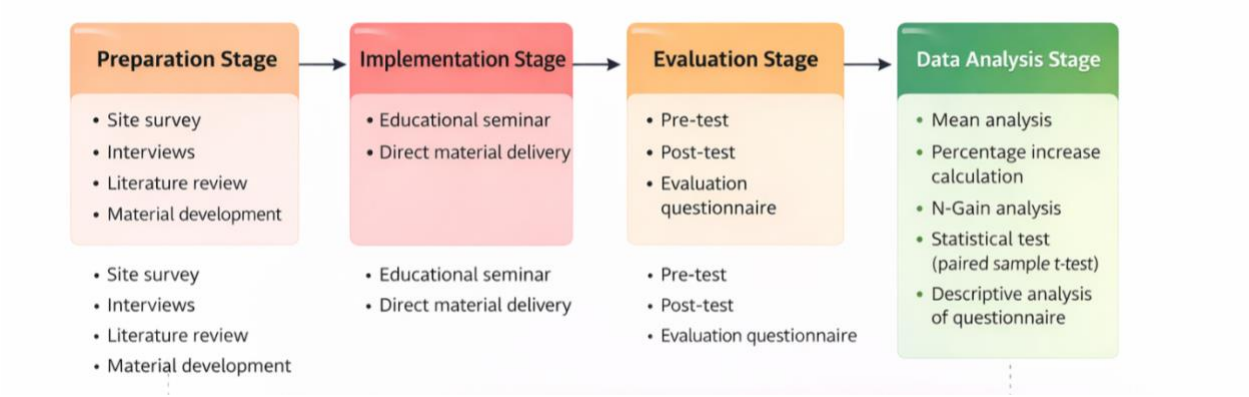

Figure 1. Flowchart of Workshop Implementation for MGMP

3. Results and Discussion

3.1 Improvement of Participants' Understanding in the MGMP Workshop

The environmental ecology learning workshop based on Geographic Information Systems (GIS) for teachers of the MGMP Geography in Wonogiri Regency was attended by 21 participants (**Figure 2**). The evaluation was conducted using a quantitative approach through pre-test and post-test, supported by questionnaires to measure participants' perceptions of the activity.

Figure 2. Environmental Ecology Learning Workshop Based on Geographic Information Systems (GIS) For Teachers of The MGMP Geography, Wonogiri

The pre-test results (**Figure 3**) indicate that most participants still had relatively limited understanding of region-based ecological concepts and the application of GIS in learning. The score distribution tended to fall within the low to moderate categories, suggesting that the utilization of geospatial technology in geography education remains suboptimal. This finding is consistent with previous studies indicating that GIS integration in education still faces challenges, particularly in terms of teachers' technical competence and limited practical experience (Kerski, 2008).

Figure 3. Pre-Test Results of MGMP Workshop Teachers.

After the workshop implementation, the post-test results (**Figure 4**) show an increase in scores among most participants, indicated by a shift in score distribution toward moderate to high categories. Descriptively, this suggests that the workshop materials were effective in improving participants' understanding of ecological concepts, basic GIS principles, and their application in learning.

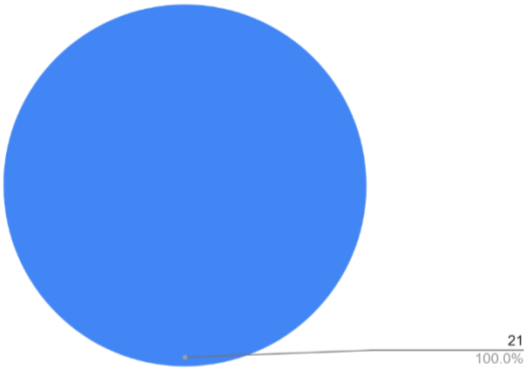

Figure 4. Post-Test Score Results of MGMP Workshop Teachers

The statistical analysis (**Table 1**) shows that the average pre-test score was 9.81, while the post-test average increased to 10.00, resulting in an improvement of 0.19 points. In percentage terms, this corresponds to a 1.94% increase. The normalized gain (N-gain) value was 0.037, which falls into the low category (Hake, 1999). Statistically, based on the paired sample t-test, the improvement was not significant ($p > 0.05$), indicating no significant difference between pre-test and post-test scores. Therefore, quantitatively, the improvement remains limited. Nevertheless, the results still indicate a tendency toward improved understanding among participants after the workshop. This finding aligns with learning theories suggesting that learning does not always produce immediate changes but requires gradual integration between new knowledge and existing cognitive structures (Ausubel, 1968).

Table 1. Results of The Paired T-Test on The Improvement From Pre-Test to Post-Test of MGMP Geography Participants in Wonogiri

Variable	Mean	N	Mean Difference	t-value	Sig. (p-value)	Intepretation
Pre-Test	9,81	21				
Post-Test	10,00	21	0,19	±1,10*	> 0,05	Not Significant

The low improvement in scores can be explained by several factors. First, the presence of a ceiling effect, where participants' initial scores were already relatively high, limiting the potential for further improvement. This condition is common in teacher training contexts, as participants generally possess relevant prior knowledge (Wang et al., 2008; Ho & Yu, 2015).

In educational contexts, the ceiling effect often occurs among participants with high initial abilities, limiting measurable improvement and resulting in low gain values despite effective learning processes (Koedel & Betts, 2010). Additionally, the ceiling effect may reduce the sensitivity of evaluation instruments in detecting learning outcomes, particularly in test- or questionnaire-based measurements (Šimkovic & Träuble, 2019). Second, the relatively short duration of the training (one day) limited the process of knowledge internalization, particularly for technical subjects such as GIS. According to Bloom's taxonomy, higher-order cognitive skills such as application and analysis require more time, practice, and experience compared to basic conceptual understanding (Bloom, 1956). Third,

the nature of GIS as a skill-based learning domain requires a continuous and practice-oriented approach. Studies suggest that effective GIS learning requires gradual stages, from conceptual introduction to project-based implementation and contextual problem-solving (kerski, 2008; sailer, 2020). Therefore, short-term training is insufficient to produce significant cognitive improvement.

3.2 Analysis of Participant Perceptions and Non-Cognitive Effectiveness

In contrast to the quantitative results, the questionnaire findings indicate that most participants responded very positively to the workshop. The majority reported that the workshop improved their understanding, provided materials that were easy to understand, offered direct benefits for classroom learning, and increased their readiness to implement GIS. These findings are supported by visual data (**Figures 5-9**), which demonstrate high levels of satisfaction, ease of comprehension, and implementation readiness. This suggests that the learning approach, which combining conceptual delivery, local case studies, and hands-on practice, was effective in enhancing participants' affective and conative aspects (Abdulwahed & Nagy, 2009). Furthermore, this phenomenon highlights a gap between cognitive outcomes and participant perceptions. According to UNESCO (2017), learning effectiveness is not solely measured by improvements in test scores but also by changes in attitudes, awareness, and readiness to act. In this context, the workshop can be considered successful in fostering positive learning experiences and practical preparedness among participants.

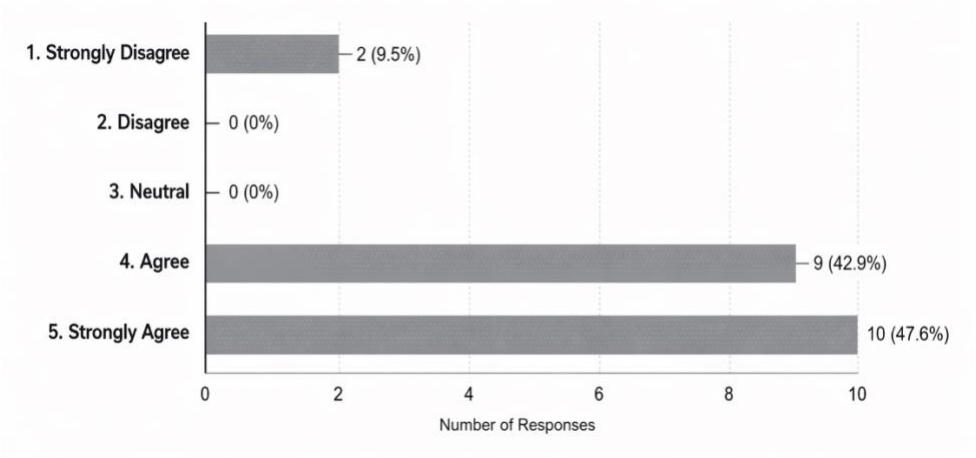

Figure 5. Participant Response on Increased Understanding of Community Service Workshop

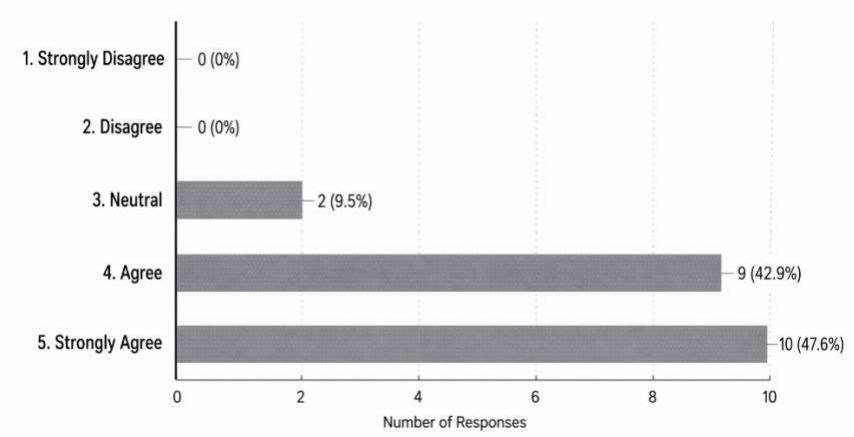

Figure 6. Participant Response on the Ease of Understanding the Workshop

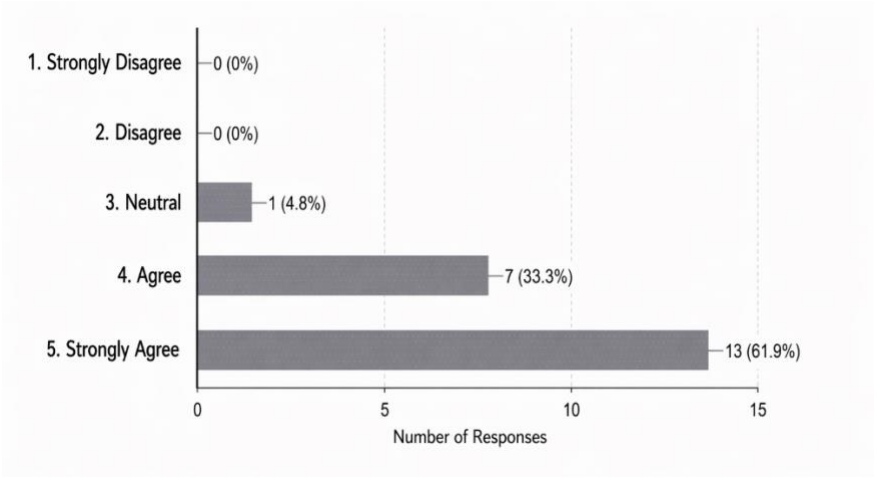

Figure 7. Participant Response on the Usefulness of the Workshop for School Learning

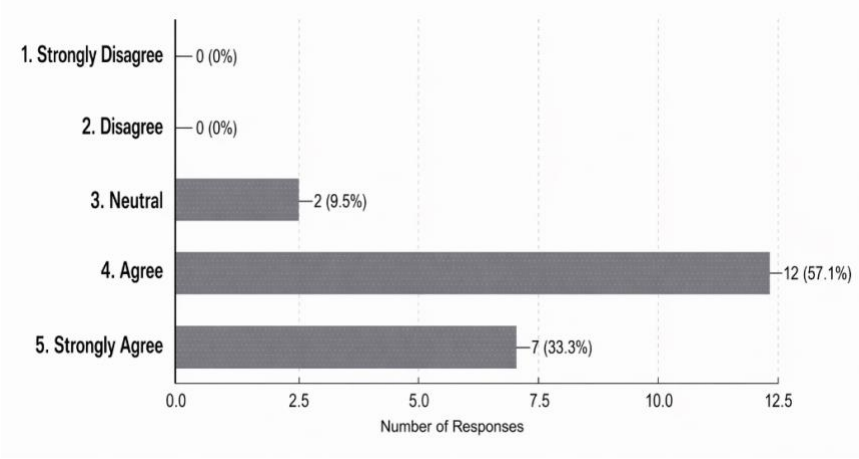

Figure 8. Participant Response on Readiness to Implement GIS in School Learning

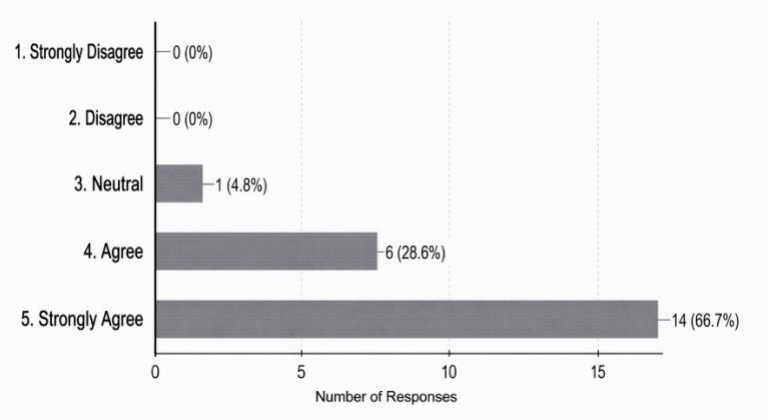

Figure 9. Participant Satisfaction with the MGMP Workshop Material Presentation

These findings are supported by visual data (**Figures 5-9**), which show high levels of satisfaction, ease of understanding, and implementation readiness. This indicates that the learning approach combining conceptual delivery, local case studies, and hands-on practice was effective in enhancing participants' affective and conative aspects (abdulwahed & nagy, 2009). This phenomenon highlights a gap between cognitive outcomes and participant perceptions. According to UNESCO (2017), learning effectiveness is not solely measured by score improvement but also by changes in attitudes, awareness, and readiness to act. In this context, the workshop can be considered successful in building awareness and readiness, although it has not yet optimally improved cognitive aspects.

The results also demonstrate that GIS integration in geography education has strong potential to enhance data-driven and spatial-based learning. GIS has been shown to support the development of spatial thinking skills and strengthen the connection between theoretical concepts and real-world conditions (García de la Vega, 2022). This workshop serves as an initial capacity-building stage in introducing geospatial-based learning approaches to teachers. In the long term, this approach has the potential to improve students' spatial thinking skills, promote problem-based learning, and connect ecological concepts with real environmental conditions. However, to achieve optimal outcomes, follow-up programs are required, including intensive training, implementation mentoring, and the development of GIS-based learning materials and modules.

Figure 10. A group photo at the end of the workshop session with the Teachers of the MGMP Geography Wonogiri.

3.3 Implications for Workshop Development

Based on the findings, this workshop can be categorized as an effective introductory stage but insufficient to produce significant cognitive changes. Therefore, a sustainable development strategy is needed, including intensive hands-on training, classroom implementation mentoring, the development of GIS-based teaching modules, and long-term evaluation of learning outcomes. With a continuous approach, it is expected that teachers' competencies in utilizing GIS can be improved more effectively and measurably.

4. Conclusion

The environmental ecology learning workshop based on Geographic Information Systems (GIS) for MGMP Geography teachers in Wonogiri Regency demonstrated a positive but limited improvement in participants' understanding, with the average pre-test score of 9.81 increasing to 10.00 in the post-test (1.94% improvement and N-gain of 0.037), and the difference was not statistically significant ($p > 0.05$). However, questionnaire results showed highly positive responses, indicating increased understanding, ease of material comprehension, perceived usefulness, and readiness to implement GIS in teaching. These

findings suggest that the workshop was more effective in enhancing affective aspects and implementation readiness rather than short-term cognitive improvement. The limited improvement was influenced by factors such as the ceiling effect, short training duration, and the skill-based nature of GIS learning, which requires sustained practice. Therefore, this activity can be considered an initial capacity-building stage in developing geospatial-based teacher competencies, which should be followed by more intensive and continuous training and mentoring programs to achieve more significant improvements.

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